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RECONNAISSANCE EVALUATION. MUNICIPAL, AND INDUSTRIAL WATER SUPPLY ASPECTS OF PROPOSED BOWMAN-HALEY PROJECT, NORTH FORK, GRAND RIVER, NORTH DAKOTA

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RECONNAISSANCE EVALUATION

MUNICIPAL, and INDUSTRIAL WATER SUPPLY ASPECTS

of

PROPOSED BOWMAN-HALEY PROJECT

North Fork, Grand River
North Dakota

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I. INTRODUCTION

Title III of Public Law 85-500, of the Federal Water Supply Act of 1958, provides authority for the Corps of Engineers to include storage for immediate and future municipal and industrial water supply in Federal multi-purpose projects. It recognizes that primary responsibility for developing water supplies rests with State and local interests, and that the Federal Government may well participate where feasible through multipurpose development projects, and cooperate in aiding development of these supplies.

The Omaha District Office of the Corps of Engineers invited Public Health Service, Region VI, to participate in investigating the municipal and industrial water supply aspects of the proposed Bowman-Haley Project in Southwestern North Dakota. This office agreed to provide a limited sanitary engineering review of data collected and studies completed or in progress on the proposed development, and to advance recommendations for further study. Studies now being conducted by the Corps of Engineers will be reflected in a Survey Report for the project, scheduled for issuance January 1, 1961.

With existing resources and in the limited time available, the Public Health Service cannot initiate additional studies and collect further data. This report utilizes much preliminary data collected and studies made by the Corps of Engineers.

II. DESCRIPTION OF AREA

Physical: The Grand River is tributary to the Missouri River in Northwestern South Dakota and Southwestern North Dakota. The subbasin is bounded by Cannonball River drainage to the north, Moreau River drainage to the south, and

Little Missouri River drainage to the west. Its area of approximately 5,700 square miles is characterized by rolling unglaciated plains, with comparatively narrow valleys. Elevations vary from approximately 3,000 feet at the headwaters of the North and South Forks to about 1,600 feet at the confluence of the Grand and Missouri Rivers. The average channel slope of the Grand River is five feet per mile.

This report is concerned with the North Fork of the Grand River, which rises in south central Bowman County, the southwesternmost county of North Dakota. The North Fork, 144 miles in length, drains 1,264 square miles in North and South Dakota before its junction with the South Fork, 209 miles above the mouth of the Grand River and ten miles upstream from Shade Hill Dam.

Spring Creek, a spring-fed stream rising northwest of Bowman, North Dakota, is the major tributary of the North Fork. It drains an area of 238 square miles in its 34-mile length before joining the North Fork, 97.2 miles from the confluence of the two forks of the Grand River.

Climate of the North Fork Basin is typical of the northern semiarid Great Plains region. Average temperatures during July and January are 70° and 14° F., respectively. Temperature extremes range from -50° to 110°F. The growing season, consistent with that usually found in this section of the country, has an average of 125 days (May 20-September 20) free of killing frost. Annual precipitation averages 14", of which 10" falls during the growing season. Annual snowfall averages 30". Over 40 years of record, average precipitation for the ten driest years is 10" and for the ten wettest years 20", with the growing season accounting for 4" and 11", respectively.

Economic: The economy of the area is predominantly dependent upon agriculture, which employs approximately 60 per cent of the workers. About one-half of the farm income is derived from field crops, chiefly wheat. Another one-third of the income results from livestock and livestock products. Towns are comparatively small and serve as marketing and distribution centers for the agricultural community. Populations of municipalities for the period 1920-1960 are presented in Table 1. Although Bucyrus, Haynes, and Hettinger are in Hidden-wood Creek drainage, their proximity to the North Fork Basin warrants inclusion in discussions of the area.

TABLE 1.

POPULATION OF MUNICIPALITIES - NORTH FORK GRAND RIVER

Municipality	Population U. S. Census				
	1920	1930	1940	1950	1960
Bowman, North Dakota	767	888	967	1,382	1,703
Bucyrus, North Dakota	113	124	117	111	60
Gascoyne, North Dakota	60	97	48	76	50
Haynes, North Dakota	113	167	210	145	111
Hettinger, North Dakota	817	1,292	1,138	1,762	1,759
Reeder, North Dakota	258	395	263	339	321
Scranton, North Dakota	212	204	277	360	358
	2,340	3,167	3,020	4,175	4,362

Although agriculture has been and probably will continue to be the principal basis for the area's economy, potential for industrial development does exist. The area is characterized by the world's largest known lignite deposits and is included within the Williston oil basin.

Transportation and communication in the North Fork Basin is facilitated by services of the Chicago, St. Paul and Pacific Railroad, East-West U. S. Highway 12, North-South U. S. Highway 85, and State Highways 32 and 8.

Because of low BTU rating and high moisture content, lignite coal is generally considered uneconomical for use as fuel at distant markets. Two producing

strip mines near Gascoyne, North Dakota, supply current domestic uses in the area. If industry is to utilize the lignite, location near the source of fuel supply is necessary.

Although exploratory work is under way for oil and natural gas, only three producing oil wells have been developed. "Dry" natural gas wells have been in production near Bowman since 1930.

An extensive uraniferous lignite deposit was recently discovered in the vicinity. Pilot plant studies have been conducted on the feasibility of extracting uranium from this source. Results of these tests appear favorable.

Extensive sheep raising in and adjacent to the North Fork drainage area indicates a potential for developing wool scouring operations.

Future industrial development in the above-mentioned fields may well hinge upon the availability of an adequate source of surface water to supplement meager ground water resources. Two private electric companies have indicated interest in building thermo-generating plants in the area. A recent research study concluded the Bowman area to be a likely location for a wool processing plant. A private corporation has expended much time and money investigating the feasibility of establishing an uraniferous lignite ore concentrating mill, presumably in the Bowman area. Development of each of these industries is contingent upon availability of an adequate water supply. If assured water and power are available, in conjuction with existing natural gas and lignite fuel supplies and transportation facilities, it is conceivable that other industry would look with favor upon the area in selecting industrial sites for processing of food and kindred products. Research in other uses for lignite also offers promise of future industrial development utilizing this plentiful raw material.

As a stimulus to future municipal growth, and as an attraction to potential industrial development, it has been proposed that a dam and reservoir on the North Fork near Haley, North Dakota, and a pipeline system, be constructed to transport surface water to augment the existing ground water supply.

III. EXISTING WATER SUPPLY

Of the municipalities listed in Table 1, Bowman, Hettinger, Reeder, and Scranton have municipally-owned water facilities. Each supply is obtained from deep wells tapping the Fox Hill aquifer. Bowman also has a shallow-dug well to supplement its deep well supply. Private domestic and farm wells in the area are generally shallow, but restricted yield and poor quality from these aquifers make it almost mandatory for municipalities to obtain water from deeper formations.

Municipal wells tapping the Fox Hill sandstone are artesian in nature. Bottoms of the wells reach elevations of 1,000' to 1,500' below the surface. Aquifer thickness, not definitely known, is reportedly 320' at a point 55 miles southeast of Hettinger. Static water levels, generally less than 400' below the ground surface, are reportedly dropping. Overdraft has not been definitely established as the cause for decline, since interference from zones of depression of nearby wells cannot be completely eliminated.

Water obtained from the deep wells of these four communities is of the same basic chemical character (Table 2). Total dissolved solids are within the range of 1,000-1,500 parts per million (ppm). In each instance, the predominant cation is sodium and the anion bicarbonate. Wells at Bowman and Scranton contain considerable concentrations of sulphate, while those at Reeder and Hettinger are comparatively free of this constituent. All of the wells contain fluoride of an

acceptable concentration with the exception of those at Hettinger, where recent analysis indicates presence of fluoride in the distribution system of up to 4.0 ppm. Hardness is quite low in the wells of Bowman, Scranton, and Reeder, and moderate at Hettinger. Alkalinity is high in all of the waters.

The bacteriological sampling record of these four communities during the period 1950-1958 is presented in Table 3. Each community should have submitted one sample per month during this period. While this requirement was not met in most cases, results of samples submitted indicate relatively satisfactory bacteriological quality.

The water supply system for Bowman consists of two deep wells and one standby dug well (48' deep by 16' in diameter). The municipal distribution system, entirely of cast iron pipe, was originally installed in 1909 and its condition is considered good, even though there is some of the original pipe still in the system. Distribution system storage is provided by a 300,000 gallon concrete reservoir and treatment consists of disinfection, which is accomplished by using a hypochlorite solution.

The estimated per capita use of water is about 80 gallons per day and it is felt that this is due to the amount of water which is available, rather than demonstrating a real use of water if the supply was unlimited. This statement is predicated on the fact that the aquifer is pumped to its maximum during the summer months.

Hettinger's original water system was placed in operation in 1919. It is also a cast iron pipe system and the source of supply is obtained by five deep wells, about 1200 feet in depth, being drilled in the Fox Hill Aquifer. Storage for the

system consists of two 50,000 gallon concrete reservoirs at ground level and one 50,000 gallon steel elevated storage. Treatment of the water is disinfection and is accomplished by a hypochlorite solution. In Hettinger there is a creamery and soft drink bottling plant on the municipal water system and this use added to the domestic use shows an estimated 109 gallon per capita per day rate. It is felt that here, also, if more water could be made available the water use per capita would be of a greater magnitude.

The municipal water system for Reeder, installed in 1946, consists of one drilled well, approximately 1,300 feet in depth, and a 50,000 gallon steel elevated storage tank. No treatment is given to this particular water. The per capita use of water is very low, as it is estimated to be only 68 gallons per day even during the period of maximum use.

Use of water by the inhabitants of Scranton, though still very low as compared to the national average, has been estimated at 125 gallons per capita per day. Water secured by a drilled well, approximately 1,185 feet deep, is not treated but the system does have a 50,000 gallon steel elevated storage tank.

IV. FUTURE WATER REQUIREMENTS

The Corps of Engineers has made a study of the area to determine the future water requirements. The Public Health Service has examined the methodology of these projections and concurs that with additional water being made available and with the utilization of the natural resources, the population of the area will probably be 15,400 by the year 2012, or fifty years after the completion of the project. The per capita water use of the area is substantially lower than the present U. S. per capita water use, 96 gpcd as against 147 gpcd. It is felt, as

pointed out previously, that this low per capita use is due to lack of available water and very little commercial and industrial activity. The prediction that the future per capita use of water in this area to meet the future population, commercial and industrial requirements would be 150 gpcd, seems to be quite conservative. This is especially true when it is predicted that the U. S. as a whole will probably be using 250 gpcd by the year 2012. The above population and gallons per capita per day indicate a need of 2,590 acre-feet of water. This total requirement would be needed on a graduated scale and so the amount of water needed to support the uraniferous lignite ore concentrating mill, estimated at 825 acre-feet for ten years, can also be supplied from the water available in the Bowman-Haley project and still have limited industrial development.

The North Dakota Water Conservation Commission has indicated that with ample water the area could support two thermo-power plants and a wool scouring plant.

If there is to be full utilization of the area resources there must be additional sources of water obtained. The State Geologist for North Dakota has stated that although it is not possible to determine the potential yield that could be obtained from the Fox Hill aquifer, present indications are that water is being mined, demonstrated by the fact that it has been necessary to lower pumps twice in the last twenty years. This lowering of the water level clearly indicates that the Bowman-Haley project is needed. The water from this project, as already pointed out, would not be sufficient for all potential uses, but if used in conjunction with the sub-surface water presently available, should make it possible for industry to make use of the natural resources of the region. Industry may find it economical

and advantageous to obtain process water of low quality requirements from the effluent of the municipal sewage treatment works at Bowman, Hettinger, Reeder, or Scranton.

TABLE 2.

CHEMICAL ANALYSES OF WATER SUPPLIES*

Analysis	Municipality - Date of Sample Collection			
	Bowman 8/12/46	Hettinger 10/29/49	Reeder 5/14/53	Scranton 1/16/52
Total Dissolved Solids - ppm	1,092	1,485	1,380	1,363
Total Alkalinity ppm as $CaCO_3$	630	710	760	664
Total Hardness ppm as $CaCO_3$	10	166	6	3
pH	8.6	8.5	8.9	9.0
Iron ppm	0.1	0.18	1.0	0.15
Calcium ppm	4.0	15.5	2.4	1.2
Magnesium ppm	-	31	-	-
Sodium ppm	445	460	414	418
Fluoride ppm	1.0	2.2	1.4	1.2
Chloride ppm	25	152	104	40
Sulfates ppm	232	-	Trace	147
Bicarbonates ppm	638	784	790	664
Carbonates ppm	-	40.8	67.2	92
Nitrates ppm	-	Trace	0.0	Trace
% Sodium	99	85.8	99.3	99.7

*Data supplied by the North Dakota Department of Health

TABLE 3.

SUMMARY OF BACTERIOLOGICAL ANALYSES OF WATER SUPPLIES*

Municipality	Year	Number of Samples Analyzed	Satisfactory Samples Number	Satisfactory Samples Percent
Bowman	1950	1	1	100
	1951	2	2	100
	1952	2	2	100
	1953	3	3	100
	1954	-	-	---
	1955	11	11	100
	1956	12	12	100
	1957	12	10	83
	**1958	6	6	100
Hettinger	1950	12	11	92
	1951	6	5	83
	1952	10	9	90
	1953	2	2	100
	1954	-	-	---
	1955	14	13	93
	1956	13	12	92
	1957	8	8	100
	**1958	6	6	100
Reeder	1950	-	-	---
	1951	2	1	50
	1952	9	7	78
	1953	9	8	89
	1954	-	-	---
	1955	10	9	90
	1956	14	11	79
	1957	11	11	100
	**1958	8	7	88
Scranton	1950	3	3	100
	1951	2	2	100
	1952	3	3	100
	1953	3	3	100
	1954	-	-	---
	1955	11	9	82
	1956	13	11	85
	1957	12	9	75
	**1958	6	6	100

*Data supplied by the North Dakota Department of Health
**Includes only months January through June

"Intent to Use" Agreements:

The Federal Water Supply Act of 1958 stipulates that before construction or modification of any project including water supply provisions, State or local interests shall agree to pay for the cost of including water supply benefits in multipurpose construction. To form a basis for planning the Bowman-Haley Project, the Corps of Engineers requested the North Dakota Water Conservation Commission to obtain indications from municipalities on their needs and intent to use waters from Bowman-Haley Reservoir. In response to this request, the community councils of Bowman, Scranton, Gascoyne, and Reeder passed resolutions expressing their desire to enter into an agreement with a water selling agency, such as a conservancy district, to purchase their fair share of such water and through these purchases to pay for costs allocated to municipal and industrial water supply. In addition, expression has been received from the International Resources Corporation indicating their requirements would approximate 720,000 gallons per day for operation of a 600-ton per day uranium concentrating mill planned for the Bowman vicinity. Indication has also been received from the Montana-Dakota Utilities Company and from the North Dakota Association of Rural Electric Cooperatives of a desire to construct thermoelectric plants in the area, presumably near present lignite mines. Although actual water use contracts for Bowman-Haley Reservoir have not been negotiated, there is evidence of a substantial current demand for additional water, and every indication is that the demand will increase during future decades.

V. POTENTIAL DEVELOPMENT TO MEET FUTURE NEEDS

Although there are no other known potential surface water supplies in the area under investigation, one method for determining feasibility of the Bowman-

Haley Project is to compare cost of water from this source with costs from hypothetical sources. In the Corps of Engineers' investigation, three such hypothetical situations were studied. The Public Health Service made an independent investigation to find other alternate sources of water that could be used in this study. These alternate sources seem to be the only possible alternates and so the results are contained herewith.

A. Little Missouri River Diversion

For purposes of the study, it was assumed that a diversion could be developed in the vicinity of Marmarth, North Dakota. To satisfy water supply requirements, such diversion would require 28 miles of 14" pipeline, 15 miles of 10" pipeline, 4 miles of 8" pipeline, and 7 miles of 6" pipeline. Pipeline division points represent reduction in needed water transmission capacity as extractions were made to satisfy demands at Bowman, Scranton, and Gascoyne, respectively.

B. Dickinson Reservoir

Although no additional water is available from this source, it was taken under study as the only other additional source of surface water supply. Because of excessive pipeline distances (62 miles from the reservoir to Scranton), cost of water from this source is exceedingly high.

In both of the above alternates it was not possible to place an exact monetary value on the cost of securing water from these sources. It is, however, quite evident from the transportation costs alone that the costs of water from these hypothetical sources would substantially exceed the cost of securing water from the proposed multipurpose reservoir.

C. Additional Water from Fox Hill Aquifer

This is the current source of supply for the four communities having municipal water systems. Although the feasibility of further development of this source of ground water has not been fully investigated geologically, it is considered as a further hypothetical source of additional supply to meet future needs. Additional wells were assumed at Bowman, Scranton, Gascoyne, and Reeder. All wells were spaced at 2,000 feet intervals and assumed to have a maximum pumping capacity of 75 gpm. To satisfy future needs, 17 wells were needed at Bowman, 2 wells at Scranton, 1 well at Gascoyne, and 2 wells at Reeder. Based on recent costs of drilling and equipping a well, the unit cost was assumed to be $42,600 per well. Assuming these costs, reasonable power costs, and related costs for water storage, delivery, and treatment, the relative cost of water supply from ground water was estimated at $200 per acre-foot as compared to a cost of $68.44 per acre-foot for delivered water from the Bowman-Haley multipurpose project.

VI. RECOMMENDED DEVELOPMENT PLAN

The proposal for developing a source of surface water supply to augment the existing inadequate ground water resource involves construction of Bowman-Haley dam and reservoir on the North Fork of the Grand River a few miles downstream from the mouth of Spring Creek. The multipurpose reservoir currently proposed will have a gross capacity of 171,000 acre-feet of storage when built to an elevation of 2,798 feet msl. The conservation pool, from which municipal and industrial water supply would be extracted, will approximate 16,000 acre-feet. Reservoir studies indicate that the average annual flow would be 2,900 acre-feet with a firm annual yield of 1,800 acre-feet. The probability of the reduced amount of water is that

this condition will occur only once in two hundred years. As the reservoir is located in an area which is known as a "water-short area" and, as this study is projected only over a 50-year period, it is felt that the 2,900 acre-foot yield would be a more realistic figure to expect. This figure could become even more realistic with the use of evaporation retarding chemicals.

The major purpose of the reservoir would be control of floods on the North Fork of the Grand River between this site and existing Shadehill Reservoir, below the junction of the North and South Forks. Purposes, in addition to municipal and industrial water supply, include fish and wildlife and recreation.

As with other developments of this sort, i.e., Dickinson Reservoir, the construction agency would contract with a distribution and marketing agency for inclusion of municipal water supply capacity and facilities in the multipurpose project. The distribution system considered in this study involved a 14" pipeline, 7.875 miles, to a central pumping station. From this station, a 14" line was routed to Bowman, a distance of 11.875 miles, and a 10" line was routed to another pumping station between Gascoyne and Scranton, a distance of 12.25 miles. From the second station, a 6" line delivered water to Scranton through a distance of 2.125 miles and an 8" line transmitted water to Gascoyne and on to Reeder through a total of 12 miles of line. Delivery requirements on an annual average basis were 1,860 gpm to the central pumping station, 1,410 gpm of which were delivered to Bowman, and 450 gpm to the Scranton-Gascoyne station. From the latter station, 250 gpm were allocated to Scranton, 50 gpm to Gascoyne, and 150 gpm to Reeder.

Delivery studies were based on making raw water available to each of the four municipalities that would be responsible for treatment and distribution to

their respective consumers. Total cost of the Bowman-Haley multipurpose raw water supply was estimated at $68.44, treated and delivered to the municipality. Single-purpose development of the Bowman-Haley Project, solely for municipal and industrial water supply, would result in an estimated cost of delivered raw water of $72.79 per acre-foot.

Water Quality

During the water year 1951-1952, the U. S. Geological Survey obtained daily water samples from the North Fork of the Grand River at Haley gauge. These samples were composited by discharge and analyzed on a weekly, biweekly, or monthly basis. The weighted average of these analyses theoretically represents the quality of 100 per cent of the runoff for this water year. Results of these analyses are presented below:

Mean annual discharge	= 143 cfs
Total dissolved solids	= 174 ppm
Total hardness as $CaCo_3$	= 56 ppm
Sodium	= 32 ppm
Boron	= 0.24 ppm
Chloride	= 1.3 ppm
Sulphate	= 49 ppm
Carbonate & bicarbonate as HCO_3	= 81 ppm
% Sodium	= 58 ppm

When the above analyses are compared with analyses of the existing water supplies of Bowman, Reeder, Scranton, and Hettinger, some similarity is noted. Basically, Grand River water is a sodium bicarbonate supply. The percent sodium, however, is considerably below that of the existing municipal supplies. Total dissolved solids are only about one-seventh as high. Hardness, while quite low, is somewhat higher than existing public supplies at all locations except Hettinger.

For surface supplies, the North Dakota State Health Department recommends treatment including coagulation, sedimentation, filtration, and disinfection prior to distribution. Since the water is of satisfactory hardness, further treatment for softening would be unwarranted, thus assuring only slight change in chemical characteristics through treatment.

When compared with other ground and many surface water supplies in North Dakota, the North Fork of the Grand is considered to represent good chemical quality. It would permit marked improvement in the quality of water currently being used by these municipalities.

Distribution system studies should take into account the necessity for treating the surface water prior to domestic use. The economics of constructing individual water treatment plants for each municipality, as opposed to a single treatment plant plus a finished water distribution system, should be considered. Water treatment facilities of the type necessary in this instance can be a significant factor in cost studies, particularly in view of maintenance and operational requirements. If the conservancy district becomes a "sales agency" for both raw and treated water, a distribution system duplicated in some portions to permit distributing both types of water may be the most economical and advantageous facility.

System Expansion

Hettinger, the largest municipality in this two-county area, is currently plagued with a water shortage. Consideration was given to solving this shortage from the Bowman-Haley Project. This could be accomplished by 1) continuation of the pipeline system or systems presently being considered, or 2) by the discharge of water through the Bowman-Haley Dam down the North Fork of the Grand River to a diversion point approximately eight miles south of Hettinger.

It is not presently felt that either of the above suggestions is entirely feasible, as the water available within the proposed project will not meet the requirements of all the communities. The area should be analyzed as a whole so that the water can be used to the best advantage of the entire area. The supplying of water from the Bowman-Haley Project would necessitate the construction of treatment works as well as costly transmission facilities. As pointed out, it is not presently considered feasible for Hettinger to use water from the Bowman-Haley Project but, since it is considered possible for this to be accomplished, it is being made a part of this report.

One other aspect should also be considered: the fluoride content of the river water is lower than the fluoride available in the present source of water. Consideration should be given to securing an optimum fluoride concentration, 1.0 ppm, if additional treatment facilities are to be built.

VII. DISCUSSION AND CONCLUSIONS

Because of the shortage of municipal and industrial water supply in the Bowman-Adams County area, and potential future industrial growth, supplemental water is needed to implement economic stability for this section of North Dakota. Additional sources of supply are extremely limited and involve transportation of water from considerable distance. The proposed Bowman-Haley Project appears to be the most feasible and economical method of satisfying present and future demands for supplemental water.

Conclusions:

1. Quality of water which will be stored in the Bowman-Haley project will permit marked improvement in the quality of water currently being used by municipalities.

2. Of the available supplies investigated, the majority of which were hypothetical studies, multipurpose development of the Bowman-Haley site appears most feasible and economical.

3. The vast deposits of lignite, including uraniferous ore, and other natural and agricultural resources in Southwestern North Dakota, constitute a significant potential for future industrial and associated municipal growth.

4. Future water demands associated with municipal and industrial growth cannot be met by the present ground water resources of the area. If economic development of the area is to occur, additional sources of water supply must be developed.

5. Full development of all available ground water supplies, and transportation of surface water from Bowman-Haley Reservoir, would enhance economic growth of this area.